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CYTOLEICHUS PENROSEI, A NEW ARACHNOID PARA-
SITE FOUND IN THE DISEASED LUNGS OF
A PRAIRIE DOG, *CYNOMYS*
LUDOVICIANUS

FRED D. WEIDMAN

On March 28, 1907, a male prairie dog, *Cynomys ludovicianus* died in the Philadelphia Zoological Gardens with acute bronchopneumonia. The inflammatory condition was recognized at the time of autopsy, the lungs being described as diffusely red, standing out well, their apical parts emphysematous and cut surface showing minute white projecting areas. The parasites forming the basis of this communication were not recognized at this time on account of their extremely small size, being among the smallest of which the writer has found record, and much smaller than the ones which were found here (Weidman, 1915) in the lungs of a monkey and upon birds. The skin bore, especially around the head and shoulders, brownish crusts which were tightly adherent to deeper parts and which, when examined microscopically, were found to contain a fungus.

The gross diagnosis of bronchopneumonia was confirmed microscopically, shown by the presence of numerous red blood cells, frequent clumps of fibrin and moderate numbers of leukocytes in the air sacs, with which a greenish brown granular material, doubtless the excrement of the mites, was intermixed. In addition to the inflammatory disease, the sections showed a high grade of emphysema and bronchiectasis (Figs. 14, 15 and 16).

That articulated parasites were also present was recognized in the microscopical sections which shortly and routinely followed the autopsy in 1907, but it was only during a recent review of prairie dog tissues in connection with another parasite of prairie dogs [*Hepaticola hepatica* (Bancroft, 1893) Hall, 1916] that their arachnoid nature was determined. During this interval (about nine years) the tissue had been preserved in alcohol, precluding experiments on transmission of the infestation and observation of living specimens, but not interfering with staining qualities of sections. These, in favorable cases, submitted parasites showing parts of all four legs (Fig. 15) of one side, thus allowing the diagnosis of arachniasis from microscopic sections alone. They are present in large numbers, almost every section containing at least part of one and generally several, and lie for the most part within air sacs, less often in bronchi. They are surrounded by no special

grade of either acute or chronic tissue reaction such as was found in cases of Wellman and Wherry (1910).

It is impossible to state how common the infestation is in these animals because so few come to autopsy. The beasts rarely die upon the surface, doubtless seeking seclusion under ground when they become sick, there to remain until they die. As a result, only two have come to autopsy in the last eleven years in spite of the numbers always on exhibition, and of these, only the one showed pulmonary parasites.

The material for the determination of the new species was obtained by finely teasing a small portion of the lungs, yielding some fifty or more fully developed specimens and no larvae or ova. Of these, the females were more numerous than the males in the proportion of two to one. They had been fixed in formaldehyd, preserved nine years in alcohol (70 per cent.), and were examined after clearing by glycerin or Farrant's medium. From the proportion of tissue examined to the total lung substance the lungs must have contained from one to several thousand parasites.

THE FEMALE

Females selected at random measured as follows:

Pubescent Females	Ovigerous Females
0.170 x 0.087 mm.	0.200 x 0.120 mm.
0.185 x 0.085 mm.	0.193 x 0.102 mm.
0.175 x 0.087 mm.	0.185 x 0.105 mm.
0.180 x 0.090 mm.	0.190 x 0.109 mm.
0.170 x 0.100 mm.	0.195 x 0.103 mm.

A female (Fig. 1) observed laterally measured 0.190 mm. in length and 0.094 mm. dorsoventrally.

The body is broadly oval, not quite twice as long as broad, not constricted, and broadest at about the middle.

It bears a dorsal shield of subtriangular form with broadly rounded angles whose base lies at a line between Coxa II anteriorly and apex almost at anus, posteriorly. In the latter region the boundary is not sharply marked because the confines pass so gradually into the general integument, but laterally it is, the shield curving ventrally here for a short distance over the lateral parietes. Anteriorly, it shows sharp separation from the anterior part of dorsum in but few specimens, notably the immature ones. With mature specimens its anterior border appears as an anteriorly directed, more or less gentle slope, and when this is very gentle the dorsum may appear to be covered by a sub-rhomboidal instead of a subtriangular shield with rounded angles. It is possible that these different appearances come about in the following way. It will be observed from the measurements given above that the mature females are of plumper form than the immature (Figs. 2

and 3), doubtless brought about by the development of the reproductive organs which produce an internal pressure resulting in expansion of the parietes. Now the anterior margin of the dorsal shield is indicated not by a ridge, nor by special difference in character, of integuments (the integument is of the same character over the whole body), but by a downward curved slope (Fig. 1), the steepness of which will be more and more reduced as the foot becomes elevated by the internal pressure. The progressive reduction of this steepness will, now, with maturation, obscure the anterior margin and consequently give more and more continuity between the shield posteriorly and the anterior dorsal integument.

The dorsum carries but one pair of hairs: long, and projecting from its anterior part close to its lateral margins at a level between Coxae I and II. Dorsal pits are large, inconstant, and observed in but few (four out of fifty) specimens. Of these the dorsal shield carries two rows at the level of Coxa III; a more anterior one consisting of two pairs of well outlined pits and an inconstant lateral one, and a more posterior row of but one pair, one pit on each side. The anterior portion of the dorsum shows seven, arranged in two irregular longitudinal rows (Figs. 2 and 3).

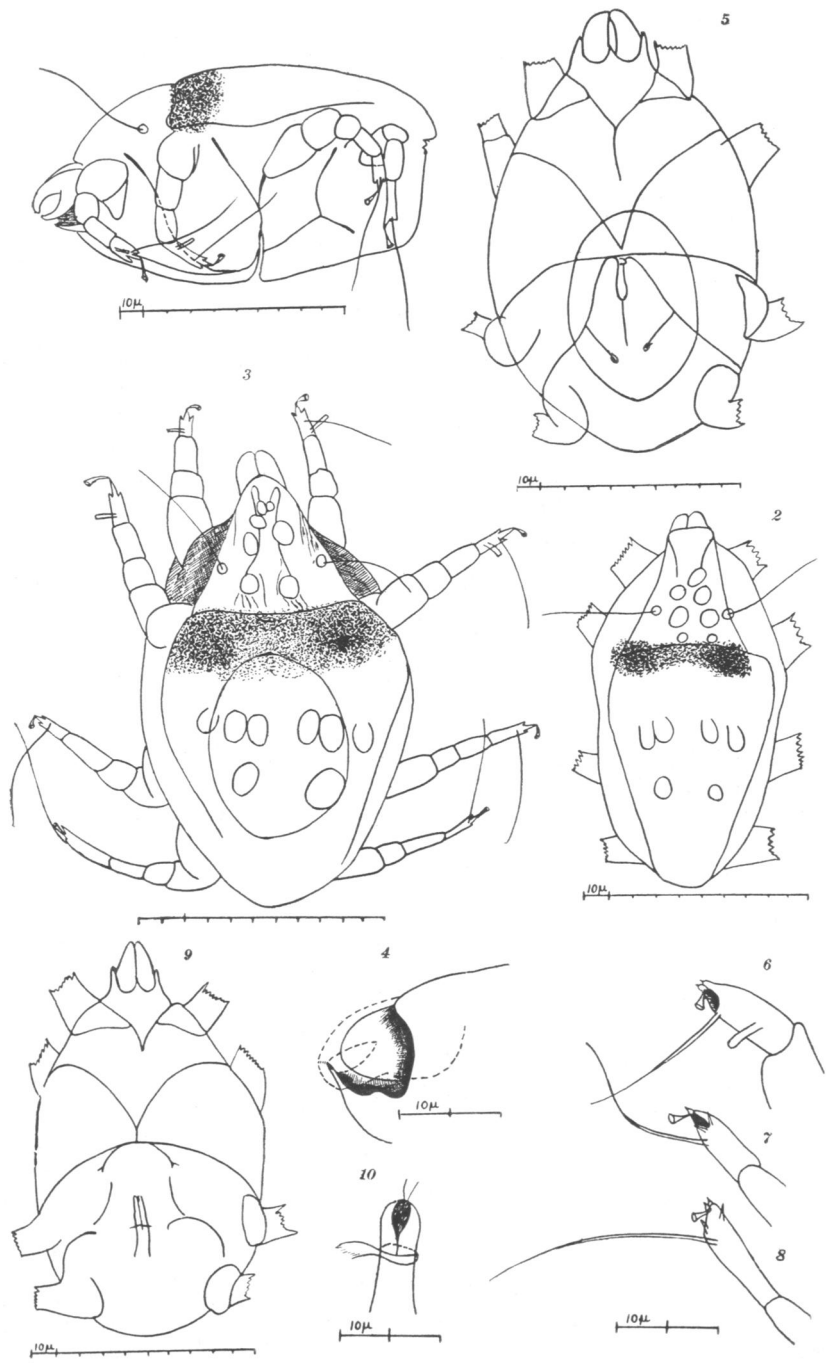
There are no eyes. The epistome is rounded anteriorly and largely covers the mouth parts as viewed dorsally. Laterally, it curves ventrally to become continuous with the hypostome, with which it forms a large tube holding the mouth parts. The hypostome shows two deep lateral scallops, with intervening median peak extending well anteriorly.

Mouth parts project but slightly beyond the body, being deeply retracted, the palpi and chelicers so closely compacted as to make their morphology indeterminate. It cannot be stated how many joints the former have, but it is most probable that they bear no hairs since some, if present, would project and be recognized in the many specimens studied. In rare cases the mandibles are recognized with untoothed chelicers (Figs. 1 and 4).

The dorsal and contiguous lateral integuments are covered by very fine, refractile, granular elevations and show no special linear markings.

The venter is divided, like that of *Sarcoptes scabiei*, into several irregular triangular areas by shallow furrows which are probably of the nature of synarthroses. They begin near the body middle, radiating laterally and curving dorsally, some nearly to the dorsal shield and all ending close to one of the coxae. (For details see Figs. 1 and 5.) The integument here, as with the dorsum, is covered by extremely fine refractile elevations of variable size, shows no linear markings, and appears to be of a soft leathery rather than chitinous nature.

PLATE 1



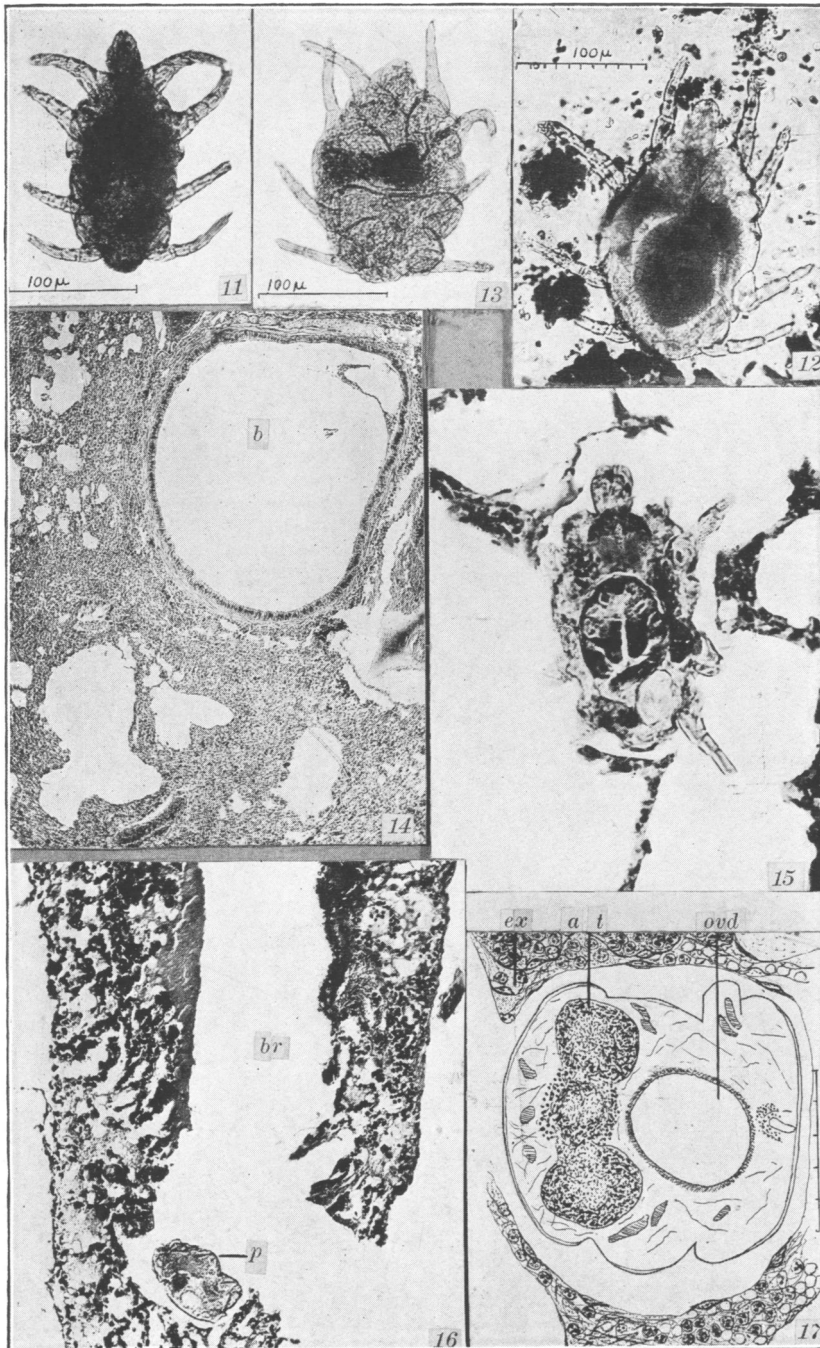
EXPLANATION OF PLATE 1

- Fig. 1.—Lateral view of female.
Fig. 2.—Dorsum of pubescent female.
Fig. 3.—Dorsum of ovigerous female. Coxae of Legs I hidden.
Fig. 4.—The rostrum, seen ventro-laterally. Dotted lines indicate the chelate mandible seen at a lower level through overlying parts. Mandible folded in joints toward mid-line.
Fig. 5.—Venter of ovigerous female.
Fig. 6.—Tarsus of Legs I and II. The seta is foreshortened.
Fig. 7.—Tarsus of Leg III.
Fig. 8.—Tarsus of Leg IV.
Fig. 9.—Venter of male.
Fig. 10.—Male external parts.

EXPLANATION OF PLATE 2

- Fig. 11.—Pubescent female. From teatings.
Fig. 12.—Ovigerous female. Also from teatings. The rounded, lighter and darker bodies are red blood cells, the darker material lung fragments.
Fig. 13.—Male. From teatings.
Fig. 14.—Very low-power view of microscopic section of lung showing dilatation of bronchus at *b* (bronchiectasis), irregular distention of some air sacs, and broncho-pneumonic exudate in others.
Fig. 15.—Very high-power view of microscopical section of lung showing longitudinal section of ovigerous female. Note distention of air sacs—emphysema.
Fig. 16.—Low-power view of microscopic section of lung showing parasite (*p*) in lumen of bronchus (*br*).
Fig. 17.—Transverse section through parasite in lung. *at*, alimentary tract; *ovd*, oviduct; *ex*, inflammatory exudate in lung. Each subdivision of scale equals 10 microns.

PLATE 2



The first pair of legs lies close to but not fused with the capitulum. There is a broad interval between it and the second pair, and a broader one between it and the last two pairs. The latter are separated from each other by about the same distance as the first two. As fixed, most of the specimens show the first pair directed anteriorly and the other three strongly flexed upon the coxæ and directed laterally and anteriorly, as shown in Figure 2. With many, however, the legs are flexed toward the middle of venter (Fig. 1), in which case the latter generally pouts, hill-like, strongly ventrally. The first pair is the shortest, measuring 0.07 mm.;¹ the other three but little longer, measuring 0.08 mm., and none of the four is as long as the body width. Each is composed of five segments, distinctly more slender in the last two legs than the first two, particularly the tarsus of Leg IV, which is at least four times as long as broad.

Only the tarsus bears special cuticular appendages. In the case of *all* four legs it bears the following: First, a long hair passing from a point well short of its distal extremity; second, three or four² minute, short, terminal spurs, the median one or two mucronate and a little in advance of the others; third, a small, delicate caroncle extending from the base of the median terminal spur. With Legs I and II only, a short, stout, rod-like seta (sense-hair) extends in addition from a point near its base (Figs. 3 and 6). Legs III and IV do not bear this structure.

The anus is terminal, at junction of dorsum and venter, and surrounded by no special appendages. Stigmal plates in spite of careful search of the abundant material, could not be found.

The vulvar orifice is ventral, median, fissural, longitudinal, lies at level of Coxa III, and ends anteriorly at the arthrosis which passes transversely at about the body middle. No ova were observed free. A specimen in the body of a female measured 80 by 65 μ .

The only internal organ recognizable through the cuticle is part of the alimentary canal, the approximate position of which is indicated by thickly placed, black or brownish-black, fine to coarse granules probably consisting of altered blood pigmentary material (hemoglobin?) which has been ingested as food. It appears over a variable area extending through a greater part of the body width under the anterior

1. All measurements from an ovigerous female 0.200 mm. long unless otherwise noted.

2. The borders of the tarsus become membranaceous at the extremity and appear to be capable, either naturally or artificially, of being folded centrally. This may superimpose the central mucronate spurs so that they appear one, but in numerous cases this possibility can surely be ruled out. We are working here under very high magnification ($\frac{1}{12}$ in. oil immersion lens) where it is often difficult to translate optical appearances into positive statements.

third of the dorsal shield, and at times for a short distance beyond it anteriorly, or farther posteriorly, on each side. Transverse sections of the parasite in lung show two lateral longitudinal tubes hugging the dorsum closely which are evidently intestine, and a single larger ventral one which is probable the oviduct (Fig. 17).

THE MALE

The male differs from the female only in its slightly smaller size, minor differences in configuration of the posterior ventral synarthrosis, and its special genital organs. The measurements of several selected at random follow:

0.175 x 0.102 mm. (Fig. 8)
0.162 x 0.109 mm.
0.170 x 0.100 mm.
0.160 x 0.105 mm.
0.155 x 0.108 mm.

The genital orifice lies ventrally, median, at the level of Coxa III, is transverse, small as compared to its female counterpart, and bordered by a narrow chitinous rim. In most cases the copulatory apparatus projects from it in an anterior direction in the form of a short heavy cylindrical piece with rounded ends. The parts are so homogeneous that finer details cannot be asserted with certainty, but it appears as though the piece were a tube whose wall is split longitudinally through its whole length anteriorly, and whose lumen contains two extremely delicate, curved, sharp-pointed spicules (Figs. 9 and 10). For differences in configuration of posterior ventral synarthrosis compare Figures 5 and 8, a female and male.

PATHOGENICITY

Since knowledge of the clinical course of the disease is lacking, postmortem findings furnish of course the only basis for judging the part played by the parasite in producing death. By studying these, it was found that all of the lesions above described were acute ones, best seen in the microscopic sections, where among other changes emphysema and bronchiectasis were described, both of which are commonly produced by severe coughing.

Now, these two changes may be caused by either acute or chronic coughs. In those cases where the cough is chronic, lasting, say, several months, it is found that fibrous overgrowths occur in addition, particularly in the walls of bronchi, and that infiltrates of lymphocytes are also sometimes associated. But none of these are seen in this case. Bronchial walls are uniformly thin, and free of cells other than those which can be explained by the nearby acute inflammation. There

exists here the *acute* forms of bronchiectasis (or bronchiolectasis) and emphysema (so-called).

It has been already noted that no ova or larva were found in the abundant material studied. It may be added that there is no important difference in size between the mature specimens. These observations, together with the lack of *chronic* pulmonary tissue changes, lead to the belief that the mites were present but a short time, certainly not long enough to reproduce, and so probably not longer than a few weeks, as *Sarcoptes scabiei* matures from the larva in about three weeks. Under these circumstances it is the reasonable thing to believe that it is the parasites which have excited the acute bronchopneumonia and so induced death.

The two cases of Wellman and Wherry concerned parasites of squirrels which were well encapsulated in tubercular nodes, i. e., had been present for some time. It is possible that the squirrels, too, had suffered from an acute attack of bronchopneumonia at the time of infestation, and if this be true for them, it should also be thought that the disease produced by *C. penrosei* may also be recovered from at times and the mites encapsulated.

The original source and mode of entry are only speculative, as discussed in the case of the monkey infestation which has been referred to earlier (1915) as occurring in these gardens.

ZOOLOGICAL POSITION

Following Banks' (1905) key, this is indicated as follows: Class, Arachnoidea; order, Acarina; superfamily, Sarcoptoidea; family, Cytoleichidae. He describes the family as consisting of two species, *Cytoleichus* (formerly *Cytodites*) *nudus*, and *Laminosioptes cysticola*, and gives family diagnosis as "In skin and cellular tissue of birds. Vulva longitudinal." He does not include in this family the original type species, *C. sarcoptoides*, Megnin, 1879, perhaps on account of the scope of his paper, or perhaps because the species has been later placed in another genus. Nor does he give the generic diagnosis of *Cytoleichus*, which I assume to be still extant, as reproduced as follows from Megnin (1879):

"Body large, orbicular, convex above, plane below, continued anteriorly by a mobile, inclined, conical, tubular rostrum covered above at its base only by an epistome provided with no appendages like joints, etc. Legs conical, robust, arranged in two groups, a cephalothoracic and an abdominal, the first only being marginal, the epimerae of the first pair alone fused to form a sternal plate, the others free; tarsi without terminal hooks, only a ventral simple ambulacrum with cylin-

drical pedicle; the tarsus of the second pair shows at all ages in both sexes a blunt cirrus directed above and outward. Ovo-viviparous acarians. Type species, *C. sarcoptoides*. Habitat, air sacs of birds (pheasants)."

Comparison of the above diagnosis with *C. penrosei* shows several important differences, in spite of which the writer has placed this parasite in the genus *Cytoleichus*, mainly because it resembles the mites placed there by Wellman and Wherry (1910) as *C. banksi*. They were found in large numbers in the lungs of two California ground squirrels (*Otospermophilus beecheyi*), each within a tubercle, and occurred both on and within the lung substance. Their description is a brief one, and so far as it goes agrees fairly with this prairie dog species, but their illustration while a simple one, is of value here in that it shows (1) the joints of the last pair of legs distinctly heavier than in the prairie dog species, and (2) the intestinal markings far posterior. The type specimen is not available for original reference since it is recorded as in the collection of Creighton Wellman, who cannot be located in spite of some correspondence. From the data at hand, *C. banksi* would seem to differ from *C. penrosei* mainly in that (1) the joints of the posterior legs are thicker; (2) it bears no short sense-hairs upon the first two pairs of legs, or (3) longer ones upon the dorsum, and (4) no dorsal shield is mentioned. It is not possible that the two prominent dorsal hairs could have been overlooked by Wellman and Wherry (1910) had they been present in the squirrel species, nor scarcely the sense-hairs on Tarsi I and II; but it is quite possible that the dorsal shield might not be considered an entity by some observers. These differences determine a new species, *C. penrosei*.³

The writer feels that *C. banksi* and *penrosei* collectively show wide enough differences from the type to warrant the construction of a new genus to include them. Thus, *C. sarcoptoides*, the type, lives in birds, the other two in rodents; *C. sarcoptoides* measures nearly three times as large (0.570 mm. by 0.440 mm.), and does not bear the long tarsal seta common to *C. banksi* and *penrosei*. He prefers, rather, not to multiply genera, but to leave this to some systematist who will study a larger group of species than the occasional medical writer.

C. penrosei nov. spec. Specific diagnosis: Grossly invisible, broadly oval, with dorsal shield and bearing one pair of long hairs anteriorly. Legs nearly equal in length, none longer than body width, each with five joints, the tarsus of each with long hair near and delicate caroncle at tip. Tarsi of Legs I and II with short stout sense-hair near base

3. Dedicated to Dr. Charles B. Penrose, the president of the Philadelphia Zoological Society.

in addition. Vulva median, longitudinal, fissural, between Coxa III. Male genital orifice in similar position, but transverse. Females average 0.193 by 0.108 mm., males, 0.164 by 0.105 mm.

Habitat, lungs of prairie dog, *Cynomys ludovicianus*.

Type specimen in Philadelphia Zoological Gardens. Autopsy No. 1044.

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